中国科学院上海天文台
Shanghai Astronomical Observatory,Chinese Academy of Sciences
上海交通大学
SHANGHAI JIAO TONG UNIVERSITY
物理与天文学院
School of Physics and Astronomy

DECaLS DR9 Cosmology Constraints from Galaxy Clustering and Weak Lensing

Haojie XU 许浩杰

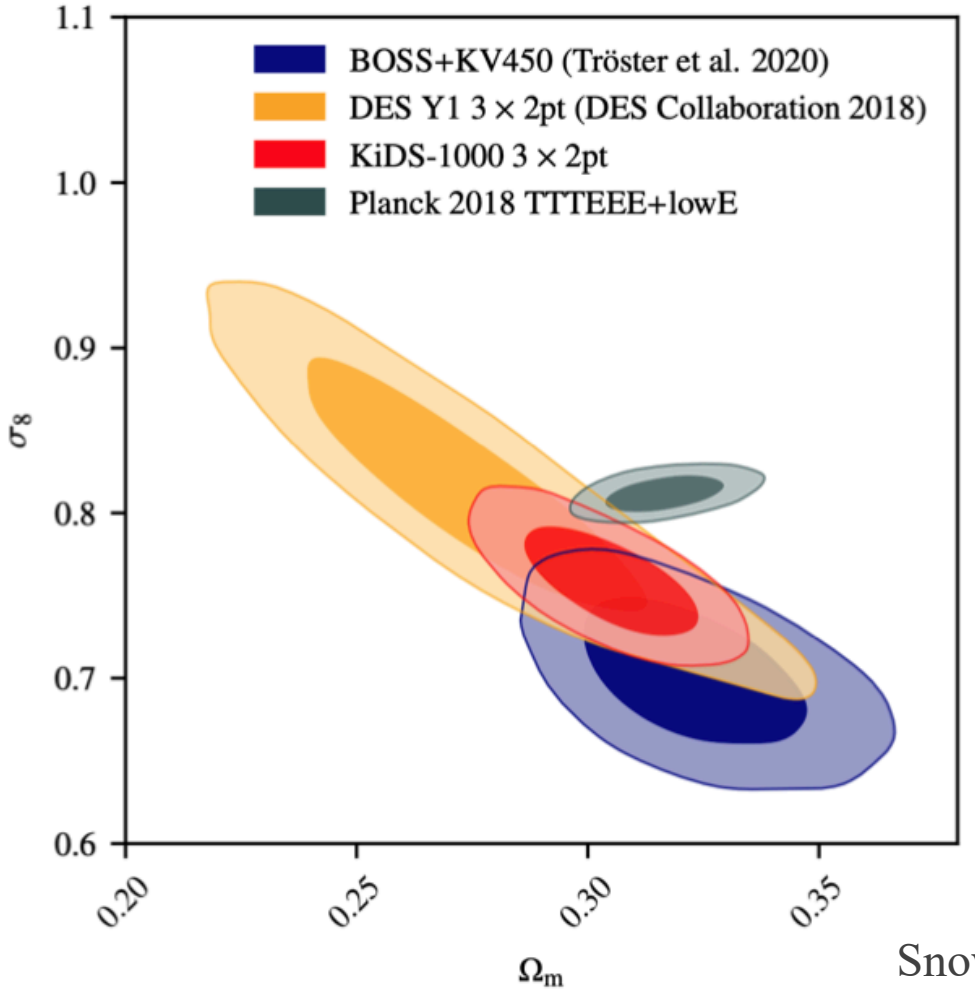
Shanghai Astronomical Observatory

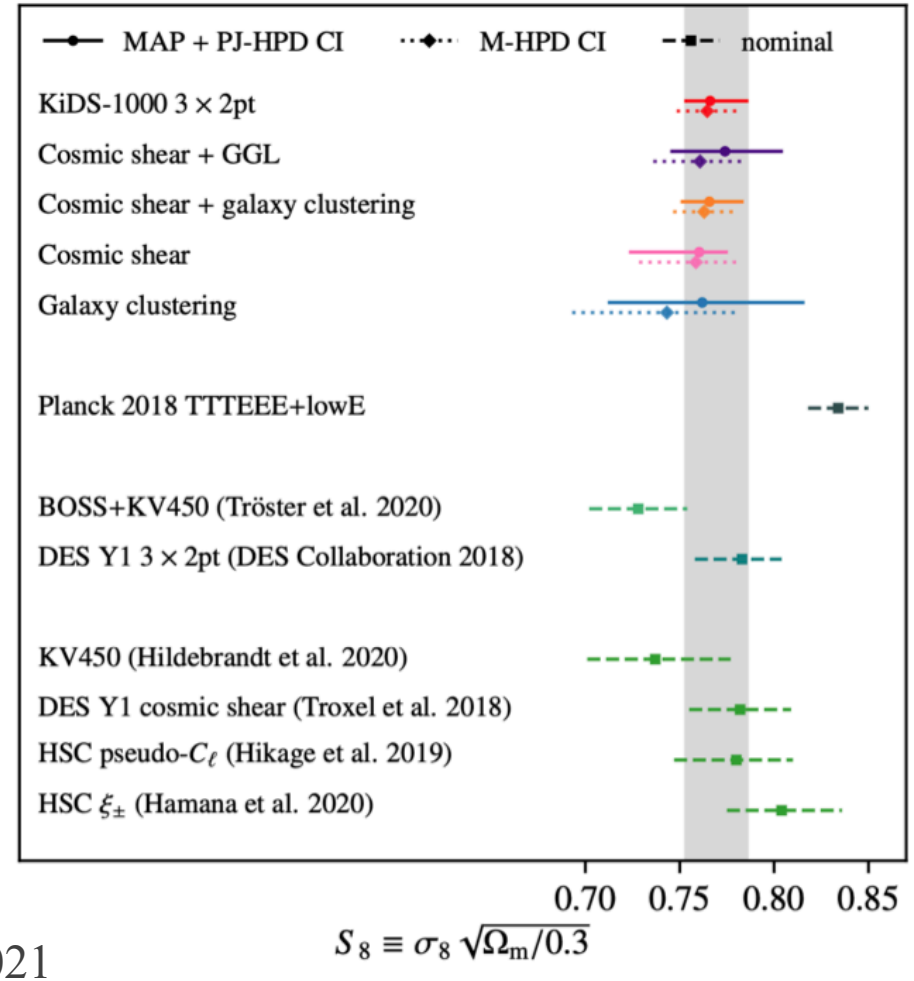
Collaboration Workshop on Cosmology and Galaxy Formation , SJTU, 06/19/2023

In main collaboration with:

Hekun Li, Jun Zhang, Xiaohu Yang, Pengjie Zhang, Min He, Yizhou Gu, Jian Qian, Ji Yao

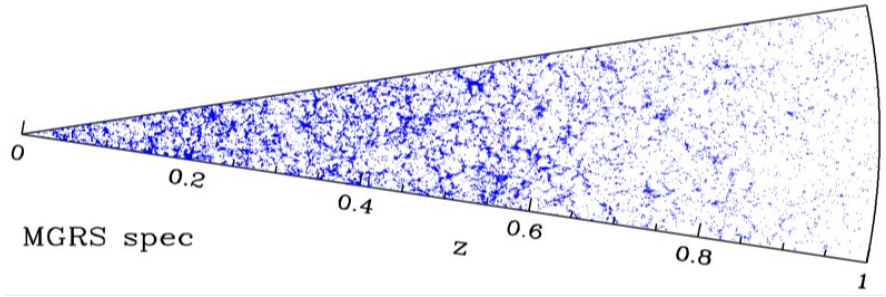
The "S_8" tension

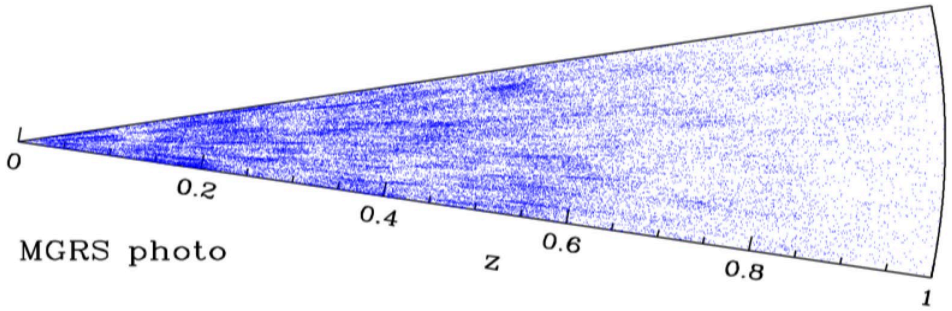




Snowmass2021

Wp measurements in photometric samples





Yang+2021, Zhou+2021

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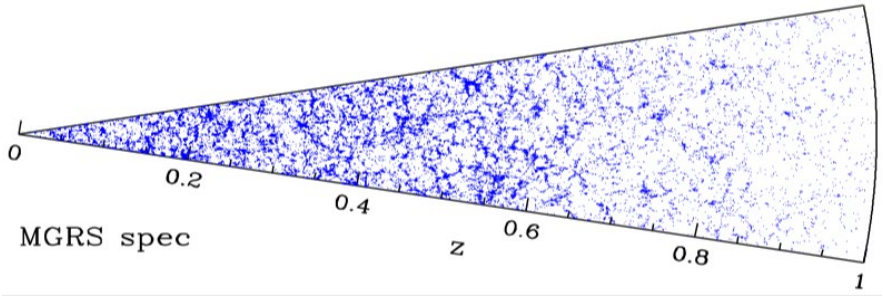
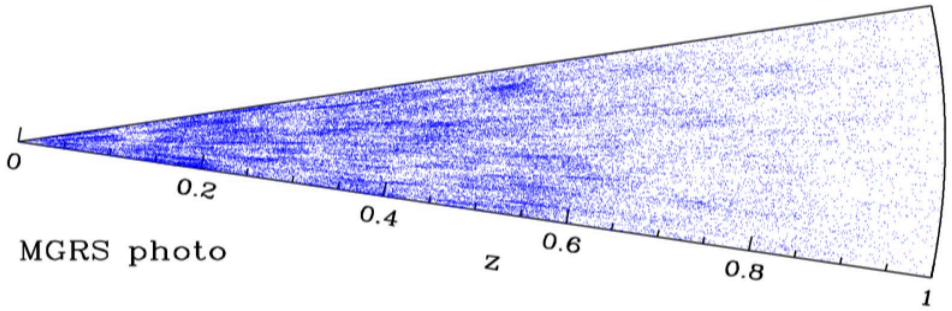
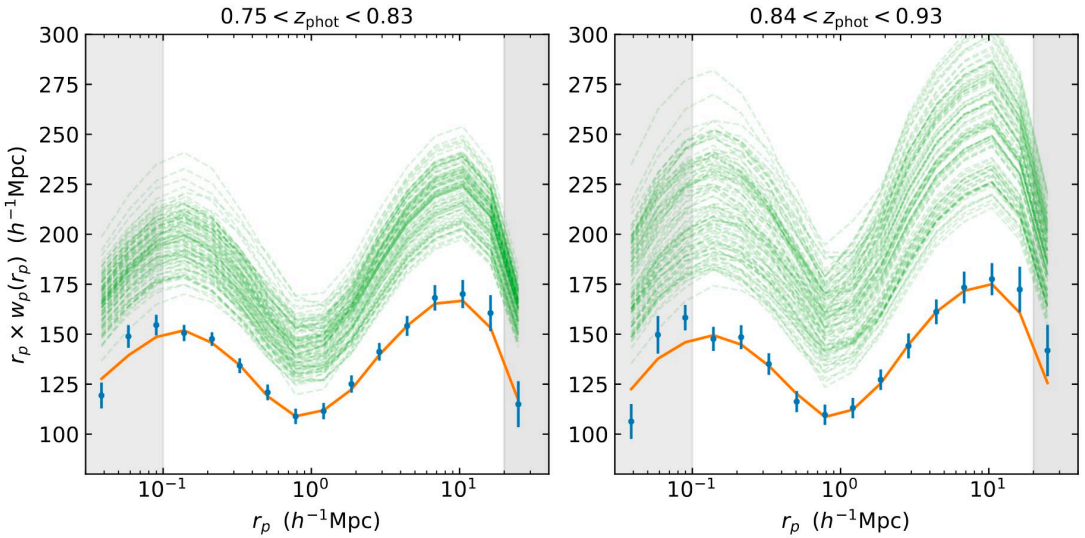
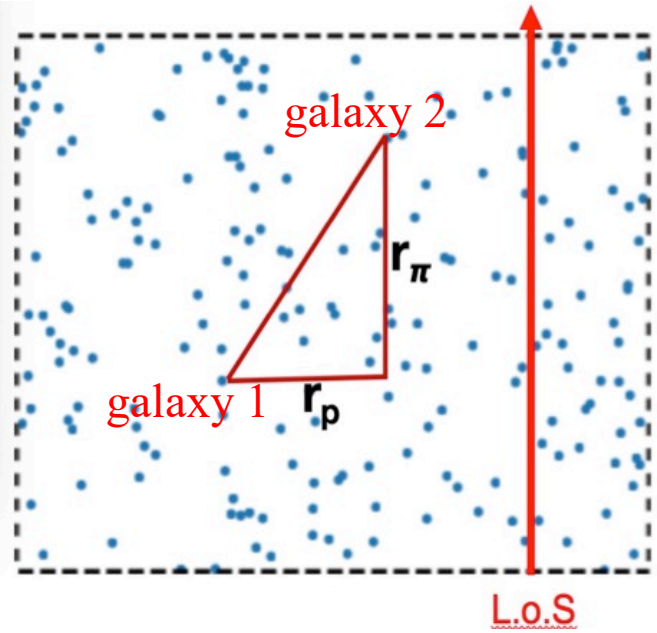






Yang+2021, Zhou+2021

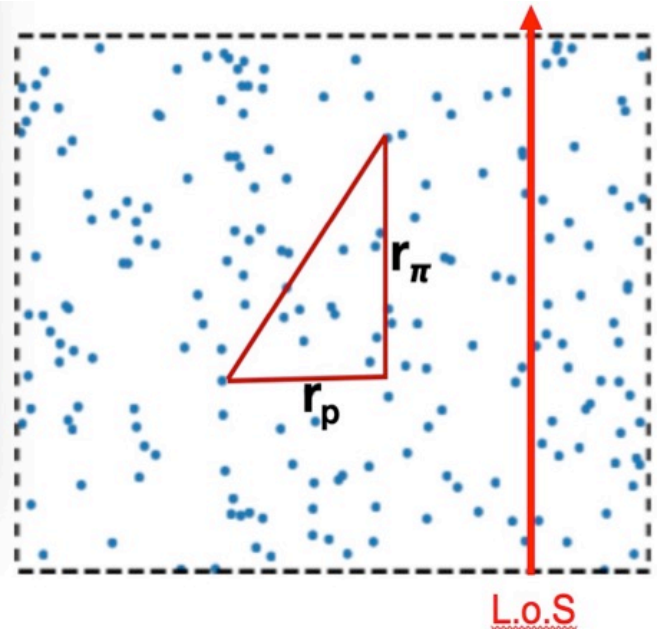
Intrinsic Wp in photometric samples



$$\sigma^2_{pair} = 2\sigma^2_{photoz}$$

Wang+2019, 2021

Intrinsic Wp in photometric samples



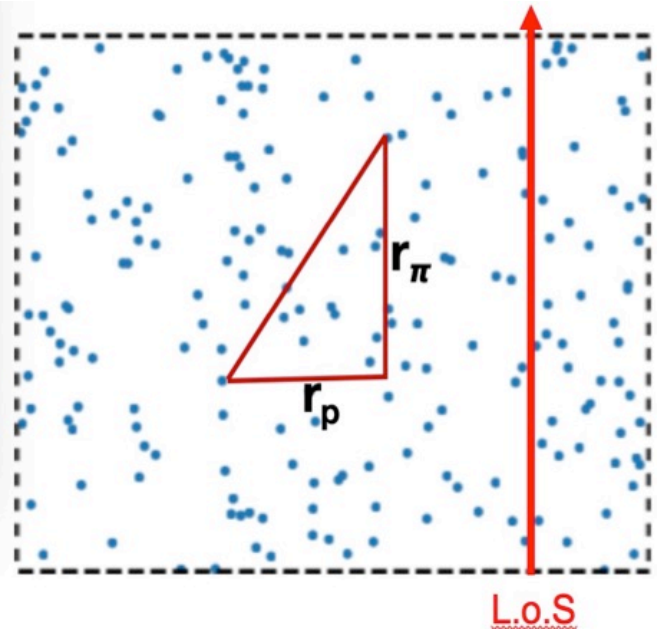
$$\sigma^2_{pair} = 2\sigma^2_{photoz}$$

$$\xi^{ph}(r_p, r_\pi) = \frac{1}{\sigma_{pair}\sqrt{2\pi}} \int_{-\infty}^{+\infty} \xi^r(r_p, r_\pi - R) \exp(-\frac{R^2}{2\sigma^2_{pair}})\, dR$$

$$W_p^{ph}(r_p|\pi_{max}) = 2\int_0^{\pi_{max}} \xi^{ph}(r_p, r_\pi)\, dr_\pi$$

Wang+2019, 2021

Intrinsic Wp in photometric samples



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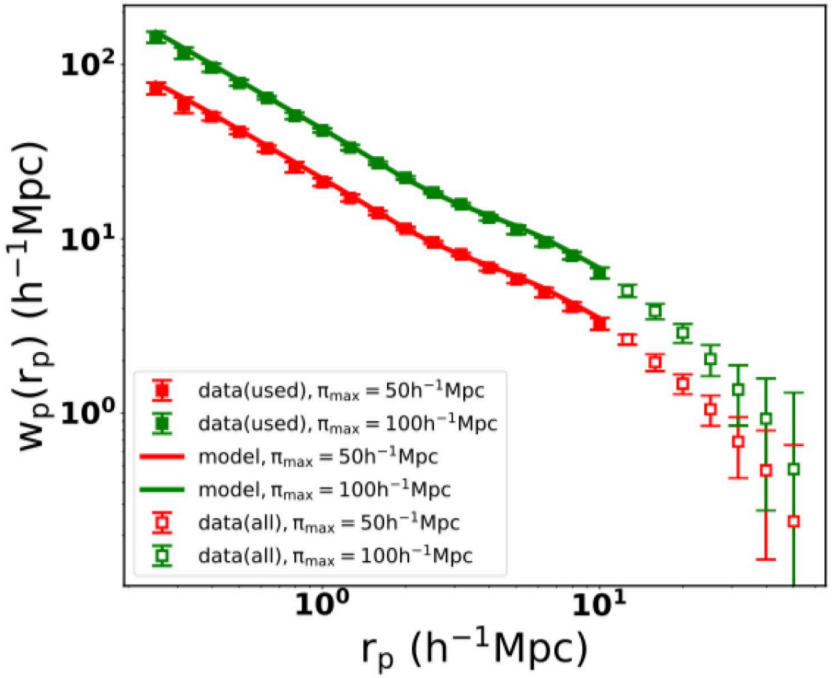
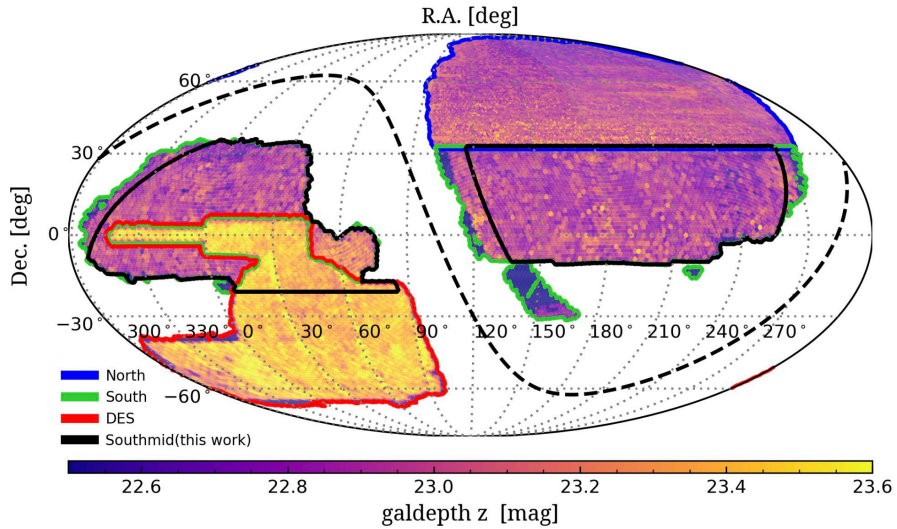


Wang+2019, 2021

DECaLS DR9

- ~10,000 sq. deg. (black contour, footprint of shear catalog)



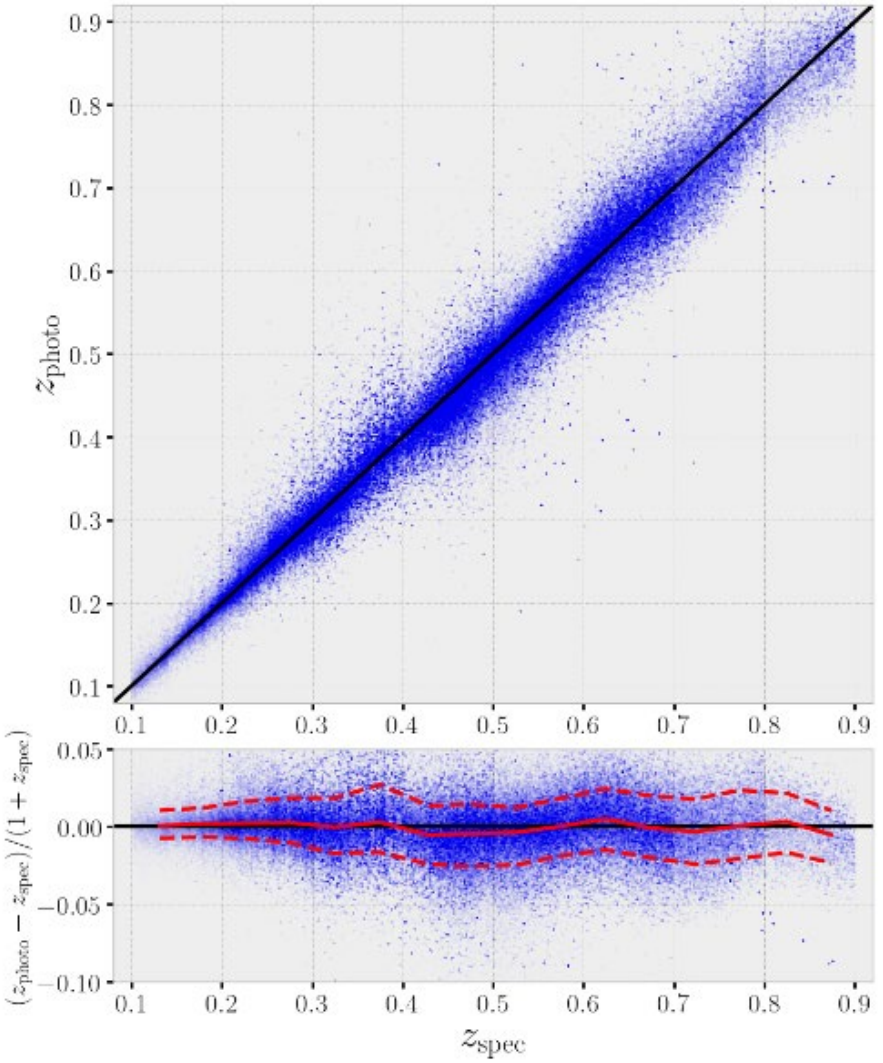
Xu+ 2023, to be submitted

DECaLS DR9

- ~10,000 sq. deg. (black contour, footprint of shear catalog)

- Photo-*z* estimation (random forest)
  - r-band magnitude, g − r color, r − z color, z −W1 color, W1 −W2 color, half-light radius, axis ratio, shape probability

- Photo-*z* quality control:
  - 0< photo-*z* < 0.9, z_{mag}<21, red galaxies
  - $\sigma_z \sim 0.02$



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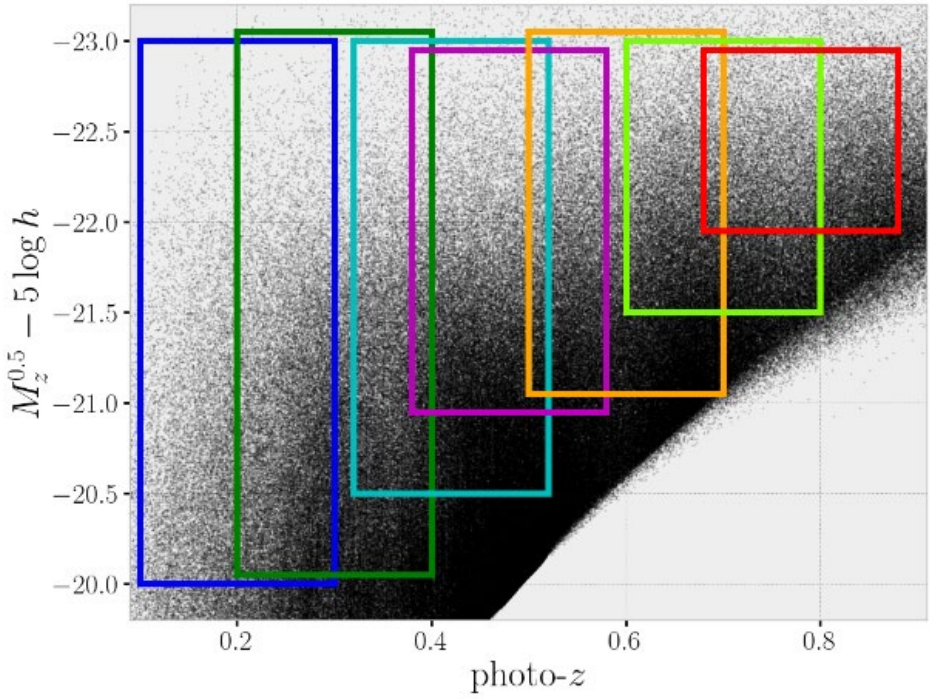
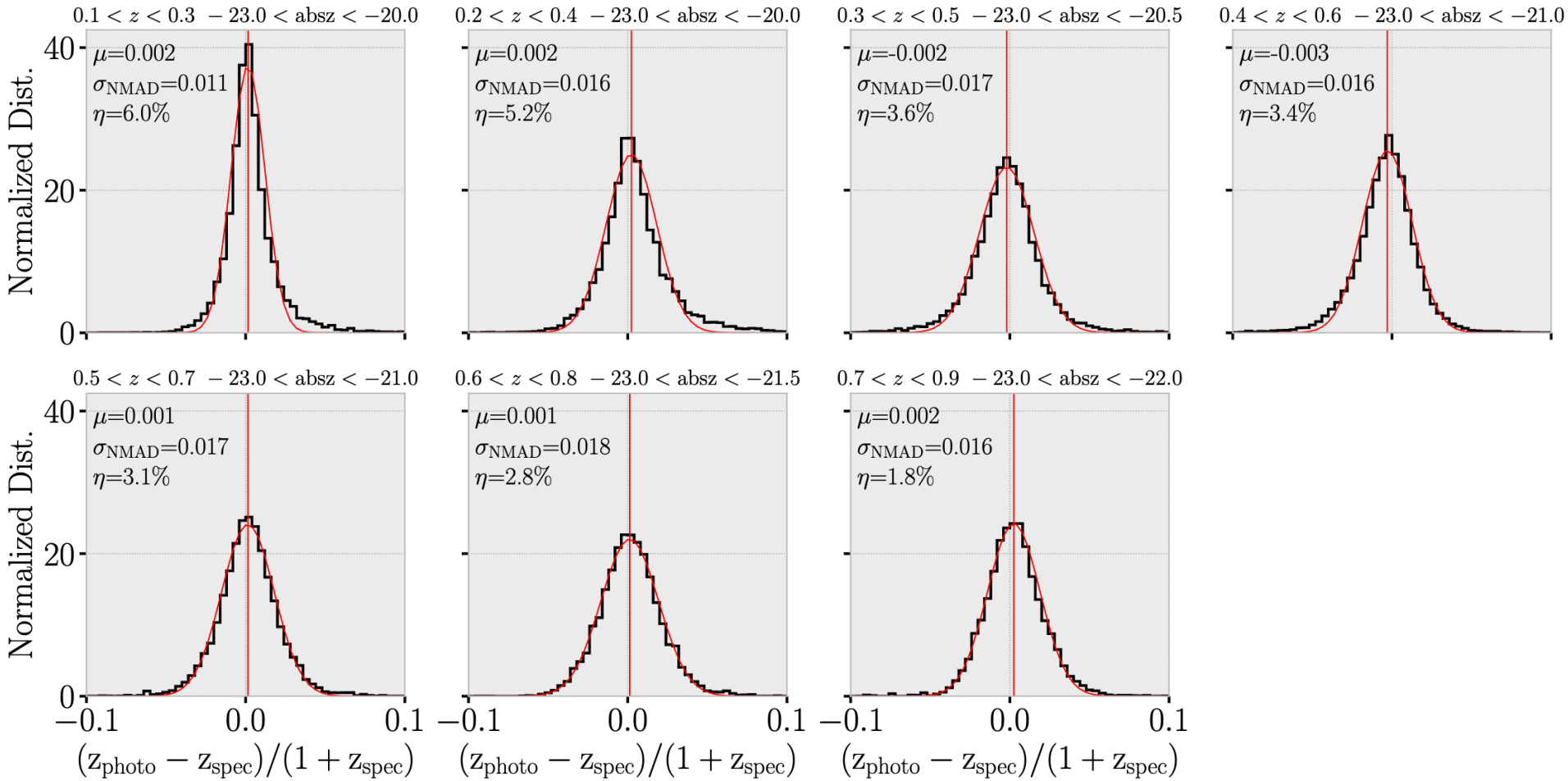


Photo-z performance of lens samples



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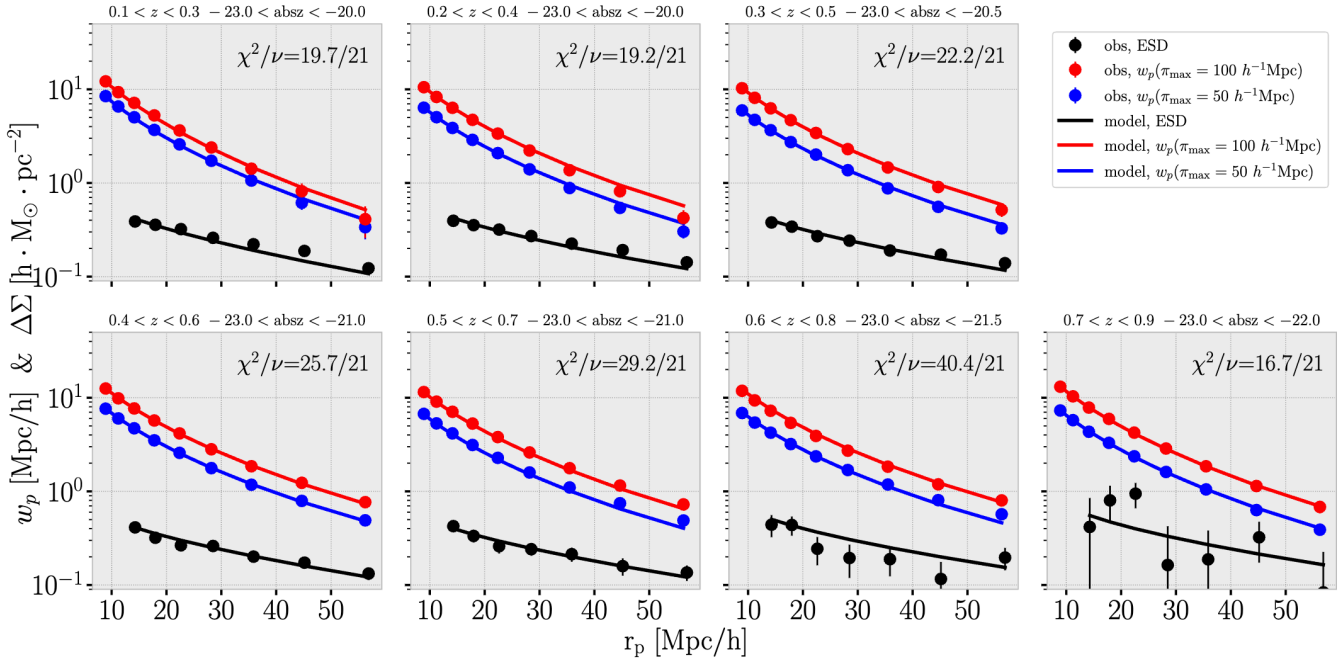
Wp and galaxy-galaxy lensing measurements



- Large-scale measurements
  - linear bias (minimal bias model)
  - scale cuts:
    - $r_p > 8$ Mpc/h for Wp
    - $r_p > 12$ Mpc/h for ESD
- Imaging systematics
- ESD measurements

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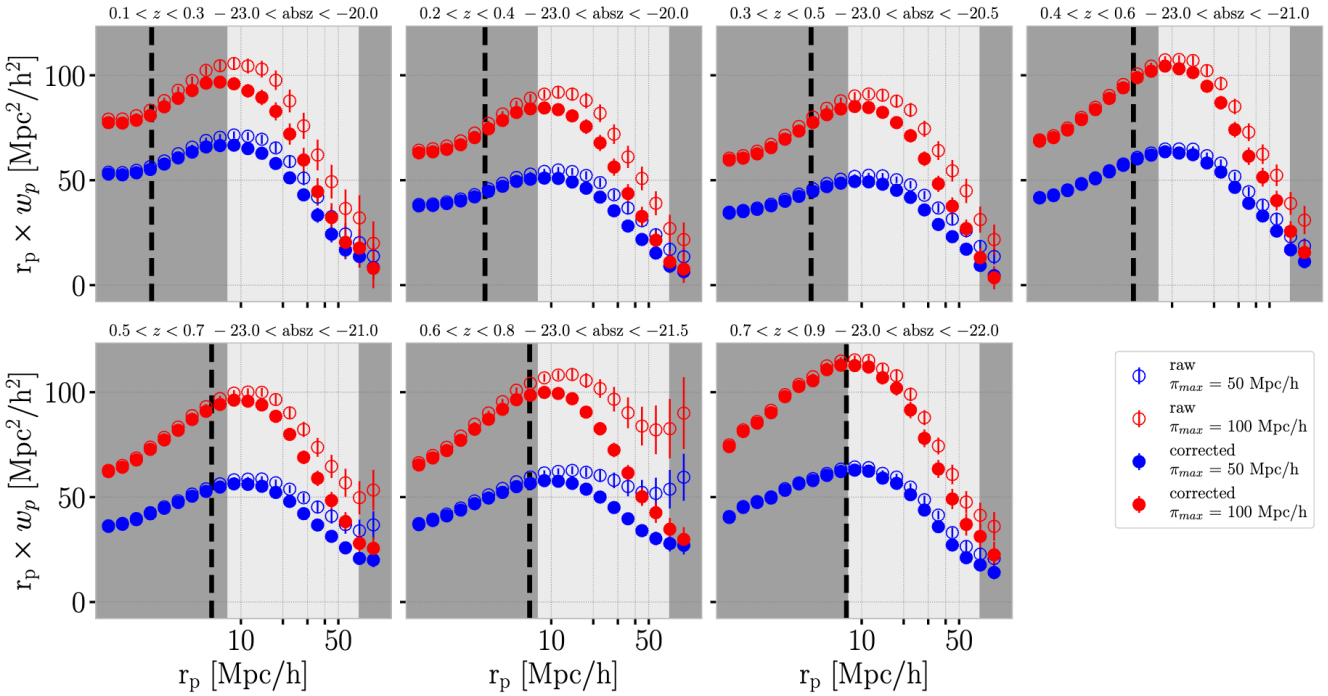
Wp and galaxy-galaxy lensing measurements



- Large-scale measurements
- Wp and Imaging systematics
  - spurious correlation in lens sample
  - no correlation between corrected lens samples with imaging quantities.
- ESD measurements

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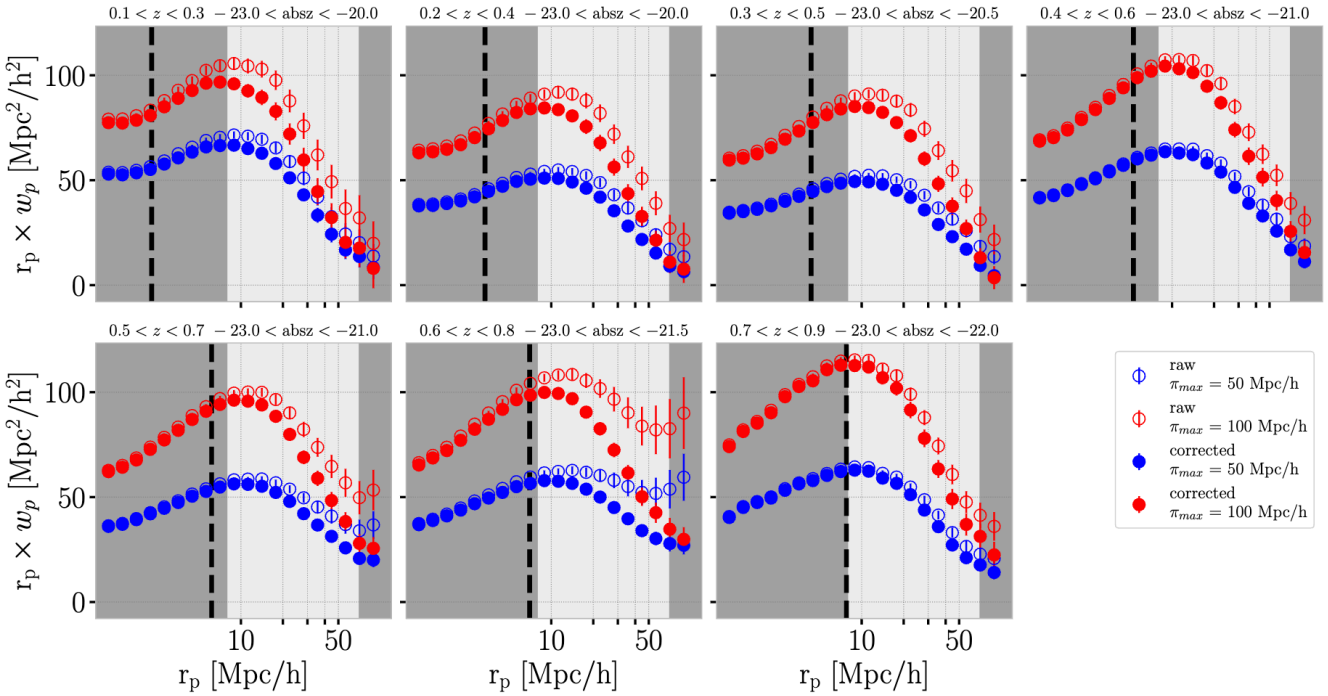
Wp and galaxy-galaxy lensing measurements



- Large-scale measurements
- Imaging systematics
- ESD measurements
  - `Fourier_Quad` pipeline
  - 10^2m = (5±3, 3±3), 10^5c = (0±3, -10±3)
  - $z_{mag} < 21$, S/N cut
  - $z_s > z_l + 0.25$
  - take photo-z distribution of source galaxies into account

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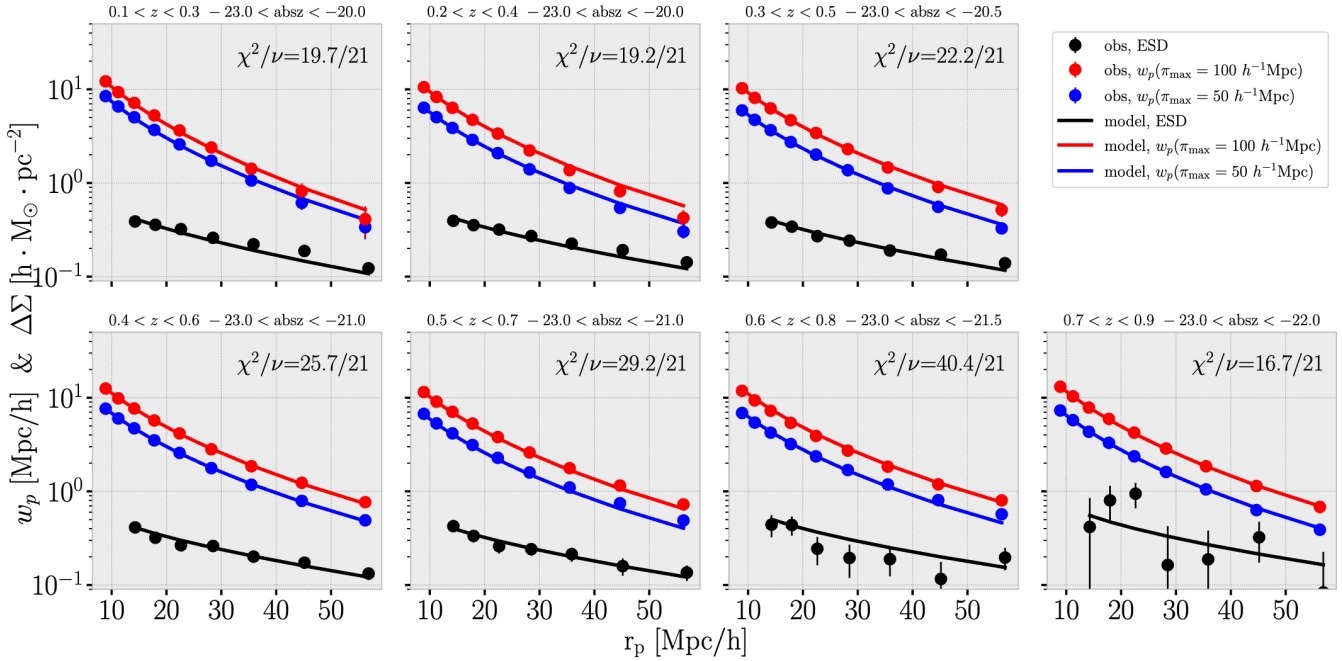
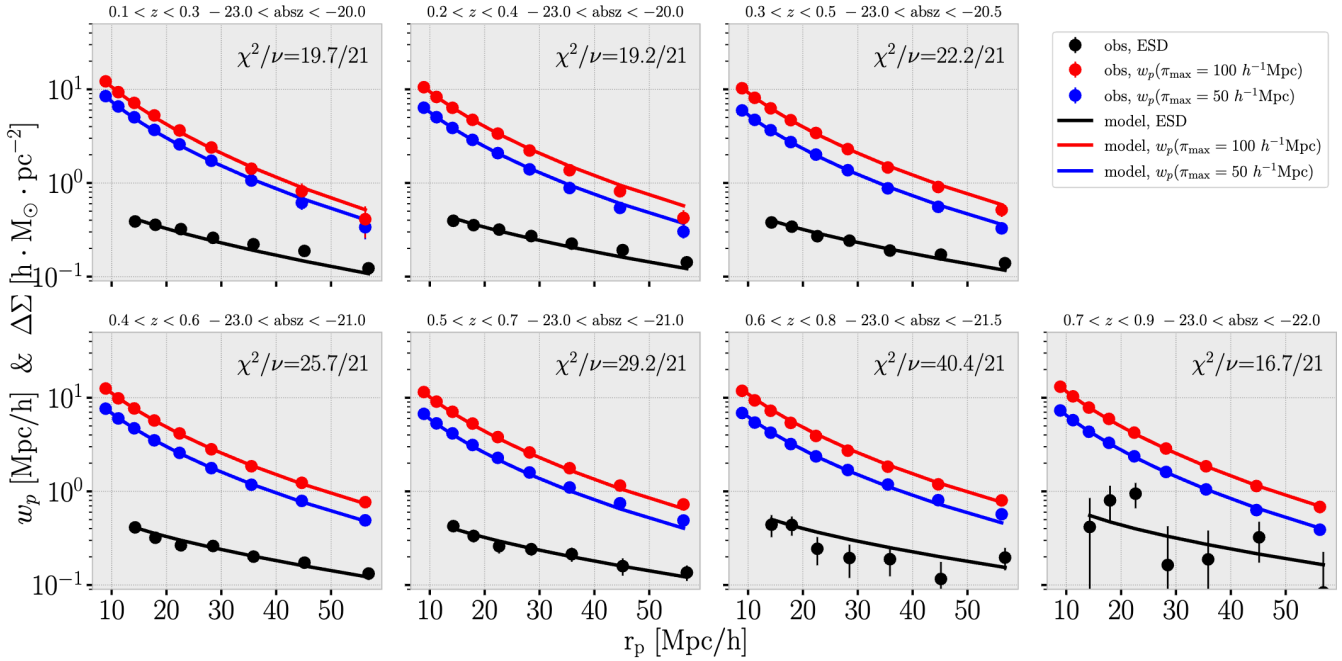
Wp and ESD modeling



- (Each lens sample) 4 free parameters
  - effective photo-z uncertainty, linear bias, omega_m, sigma_8

Xu+ 2023, to be submitted

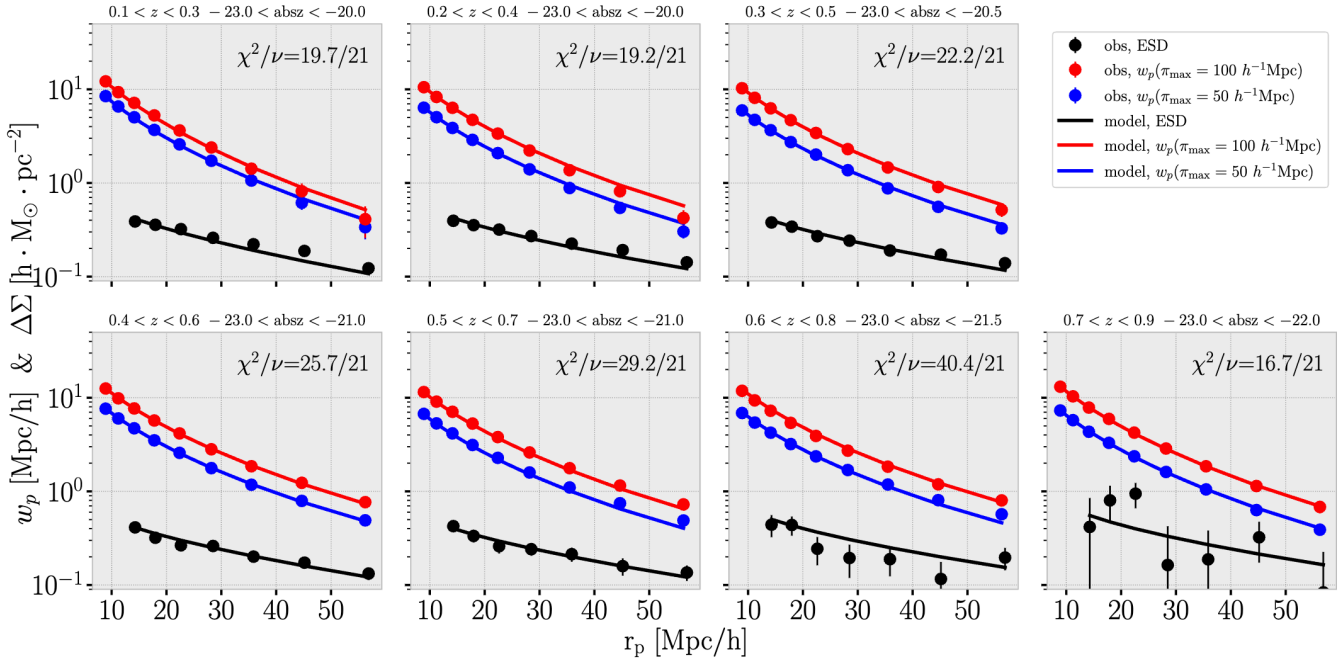
Wp and ESD modeling



- (Each lens sample) 4 free parameters
  - effective photo-*z* uncertainty, linear bias, omega_m, sigma_8
- Wp modeling
  - Gaussian photo-*z*
  - *halofit* nonlinear power spectrum
  - residual redshift-space distortion

Xu+ 2023, to be submitted

Wp and ESD modeling



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  - effective photo-*z* uncertainty, linear bias, omega_m, sigma_8
- Wp modeling
  - Gaussian photo-*z*
  - *halofit* nonlinear power spectrum
  - residual redshift-space distortion
- ESD modeling
  - unity cross correlation coefficient
  - magnification bias
    - fixed luminosity slope
    - mean lens/source redshift

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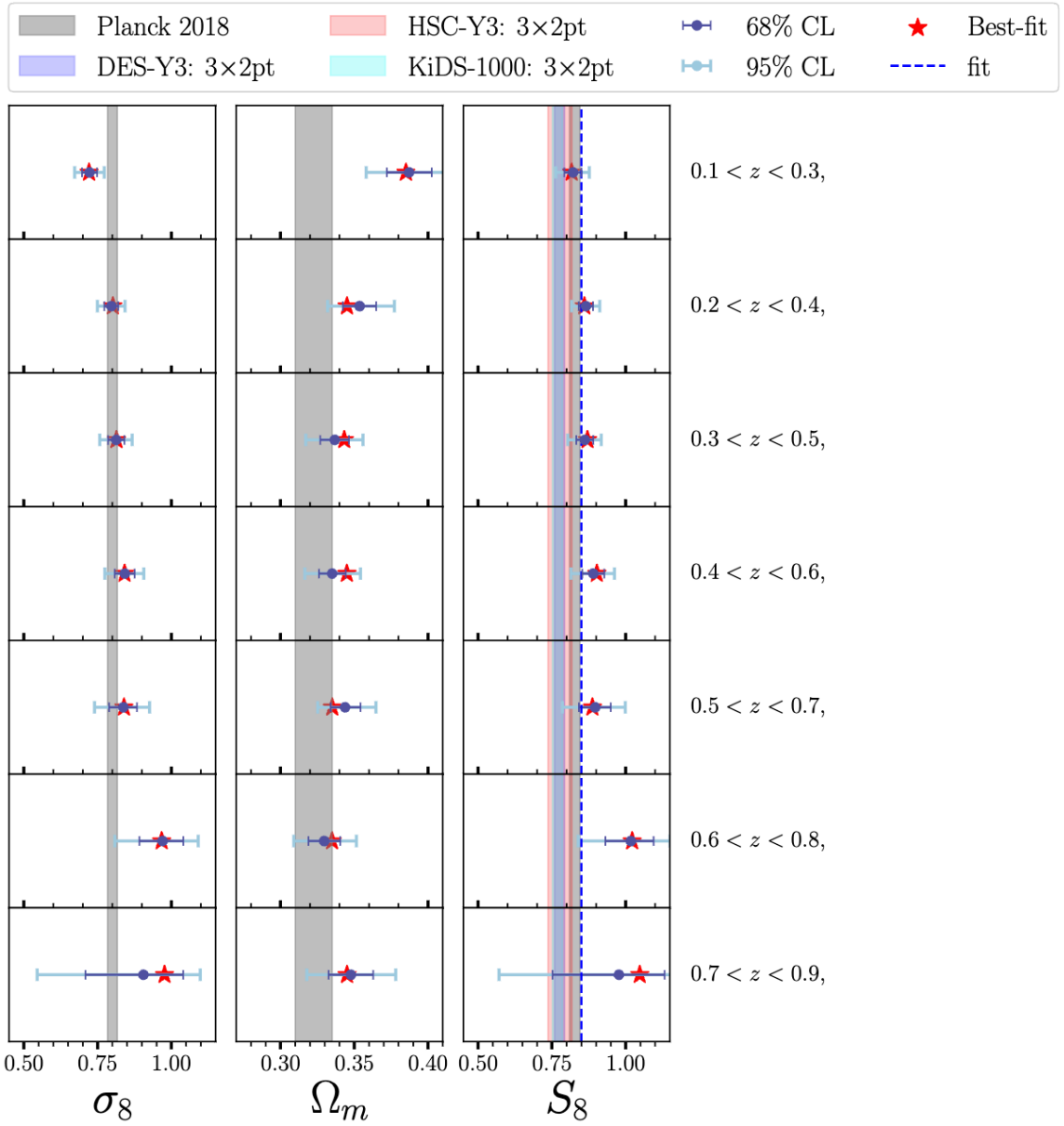
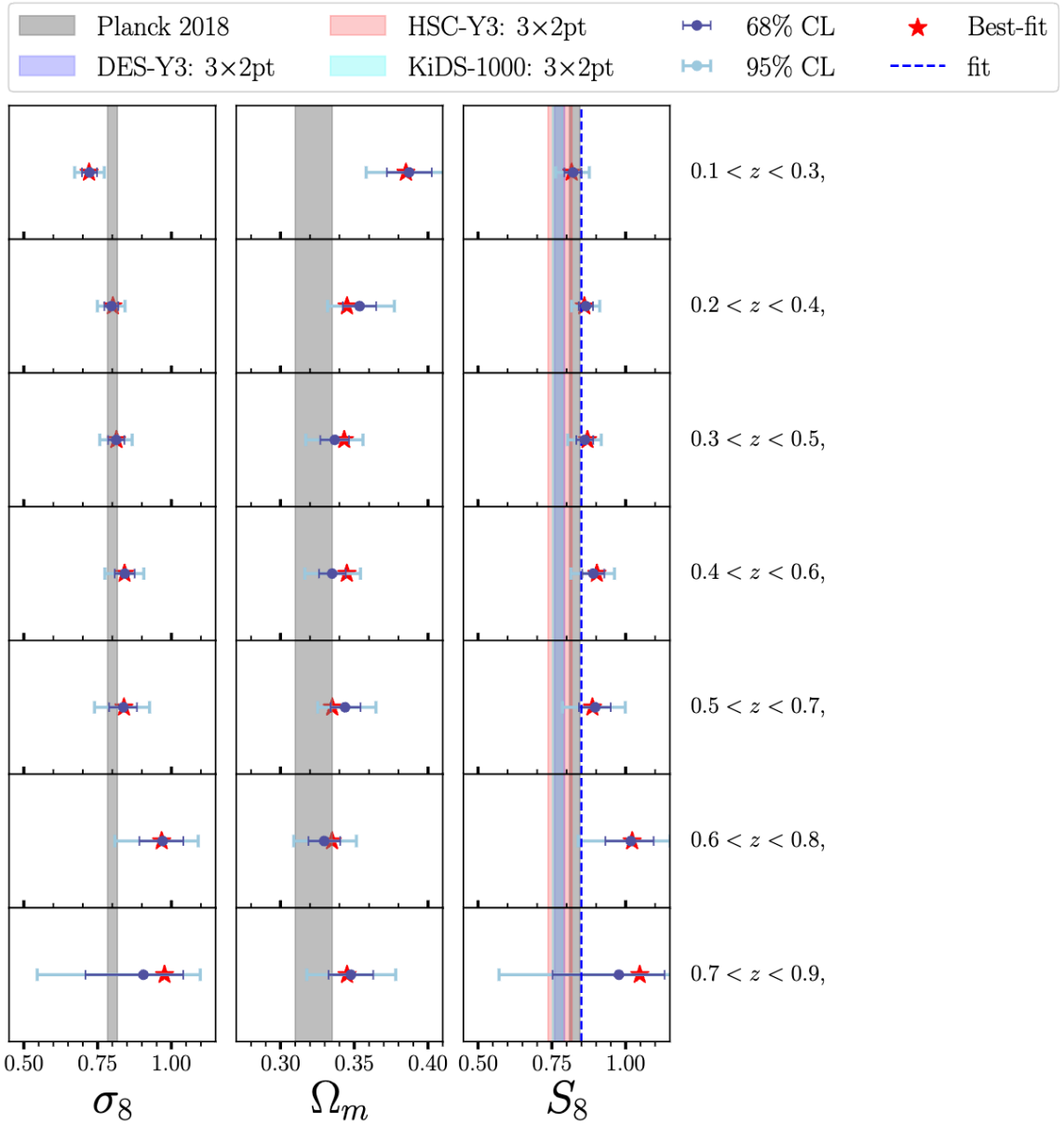
Cosmological constraints



- Tight constraints in low redshifts

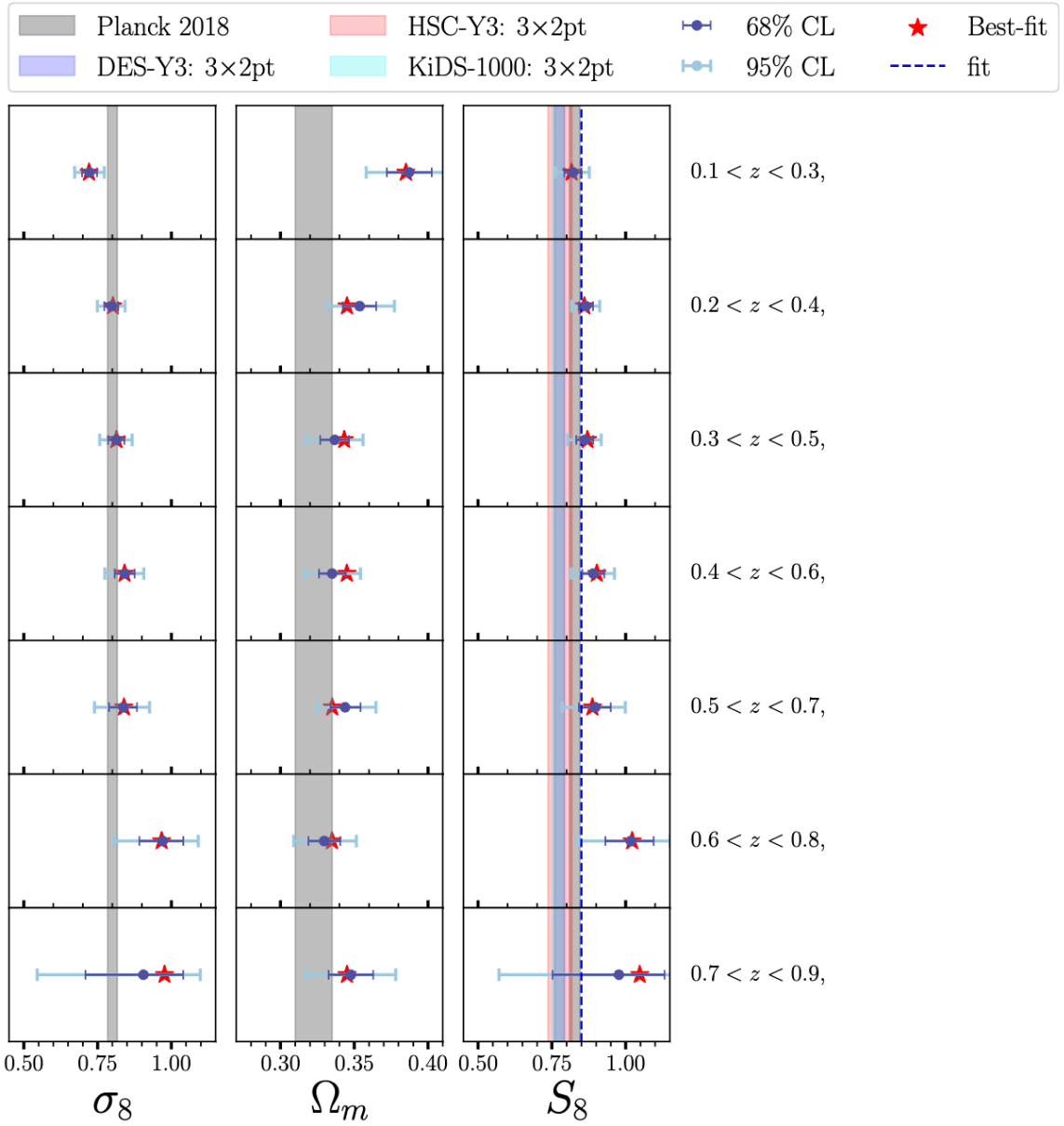
  $\sigma S_8 \sim 0.02$

Cosmological constraints



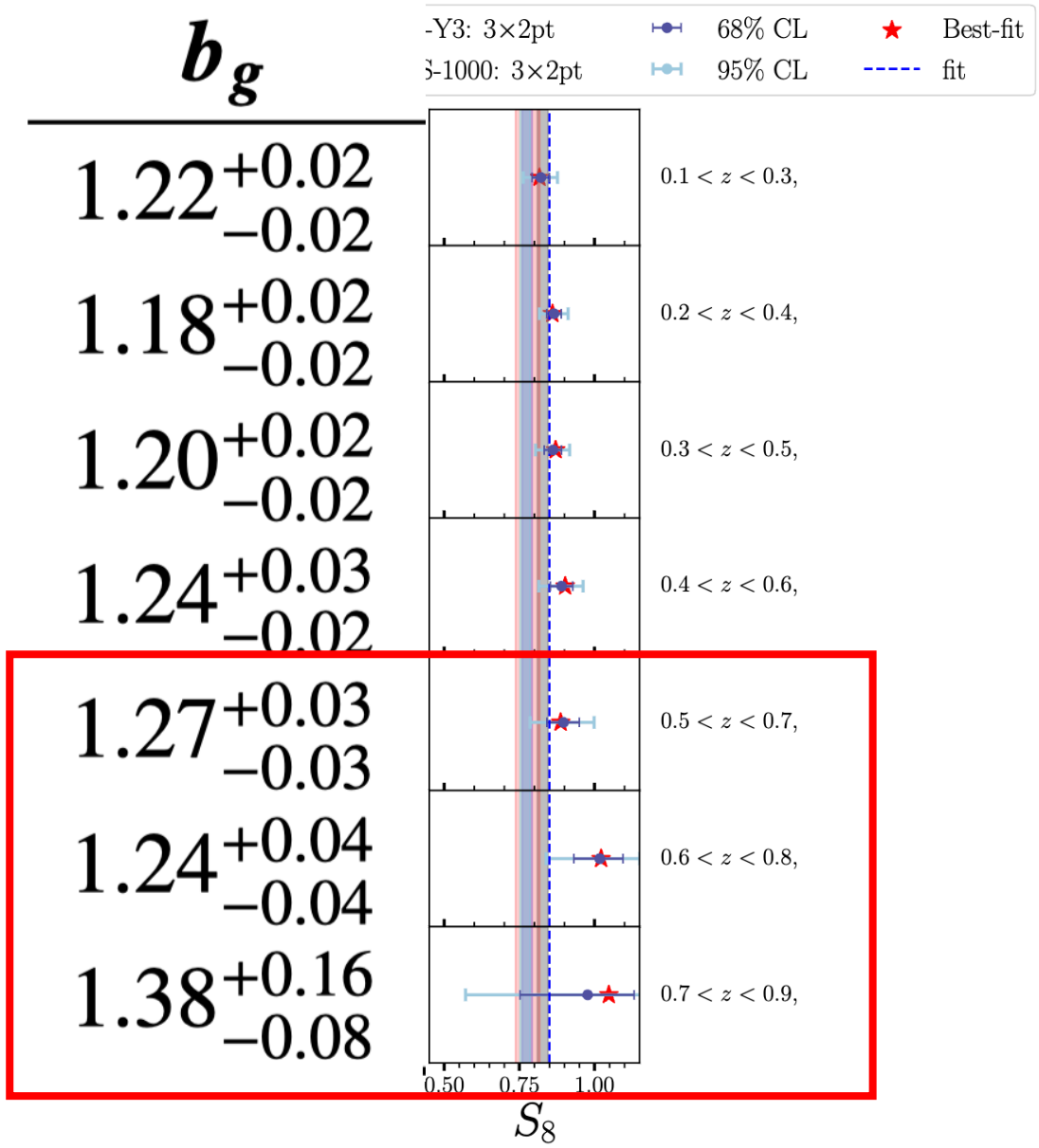
- Tight constraints in low redshifts
- Consistent with Planck results

Cosmological constraints



- Tight constraints in low redshifts
- Consistent with Planck results
- Mild trend of S_8 dependence on redshift

Cosmological constraints



- Tight constraints in low redshifts
- Consistent with Planck results
- Mild trend of S_8 dependence on redshift
- Underestimated galaxy bias in high redshifts

Possible caveats

- Imaging systematics
- Shape and ESD measurements

Xu+ 2023, to be submitted

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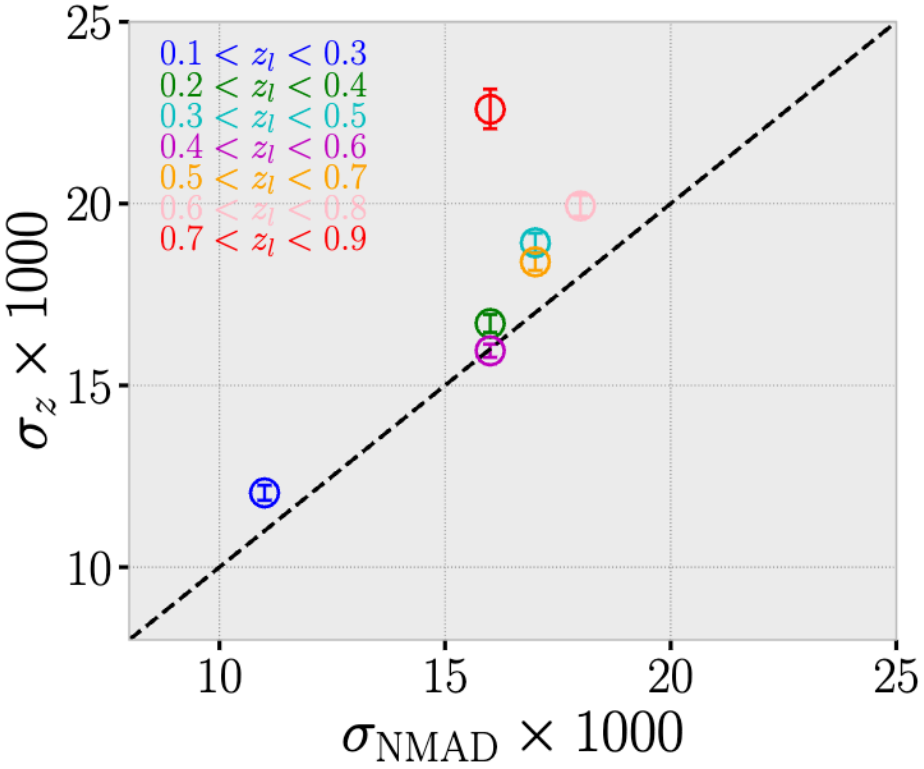
- Covariance matrix
- Incorporate the statistical uncertainties of Planck constraints
- …

Two tests



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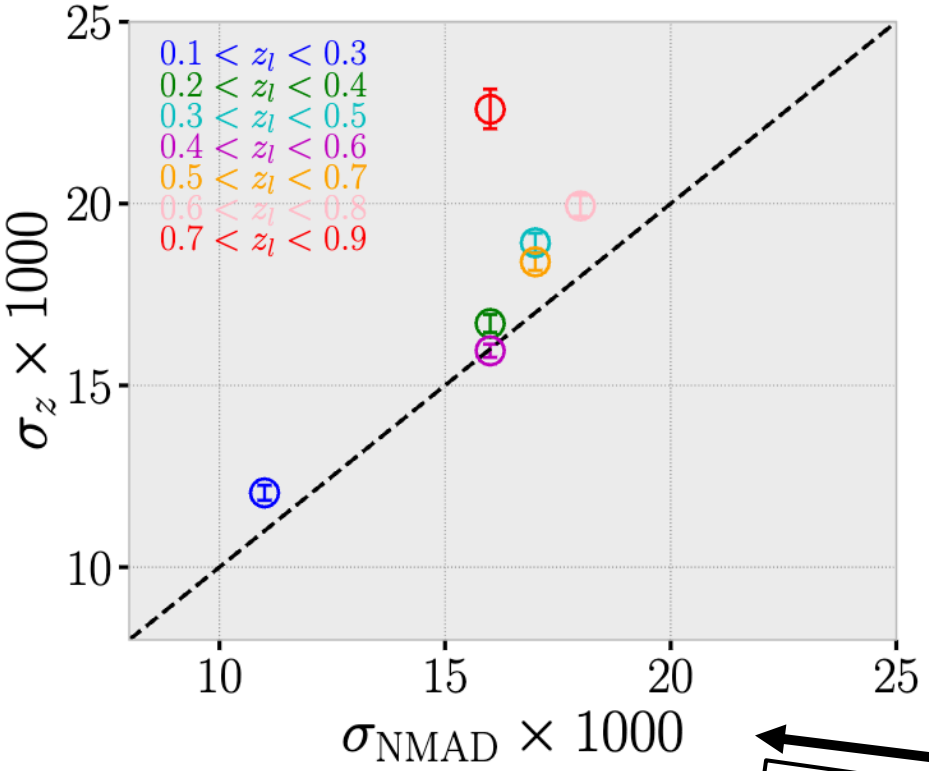
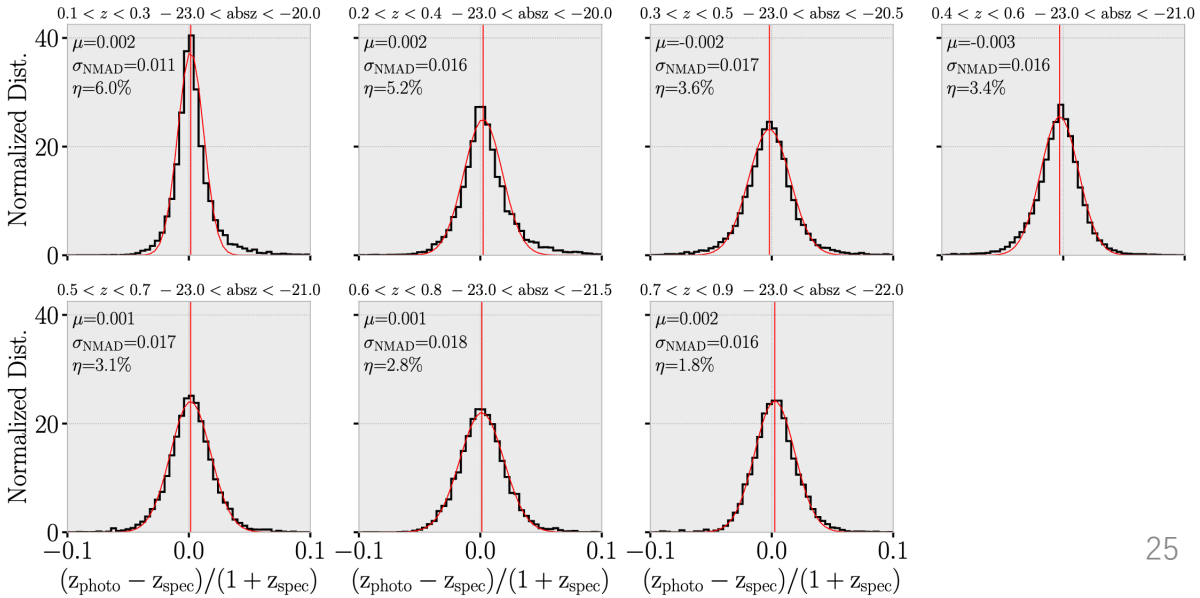


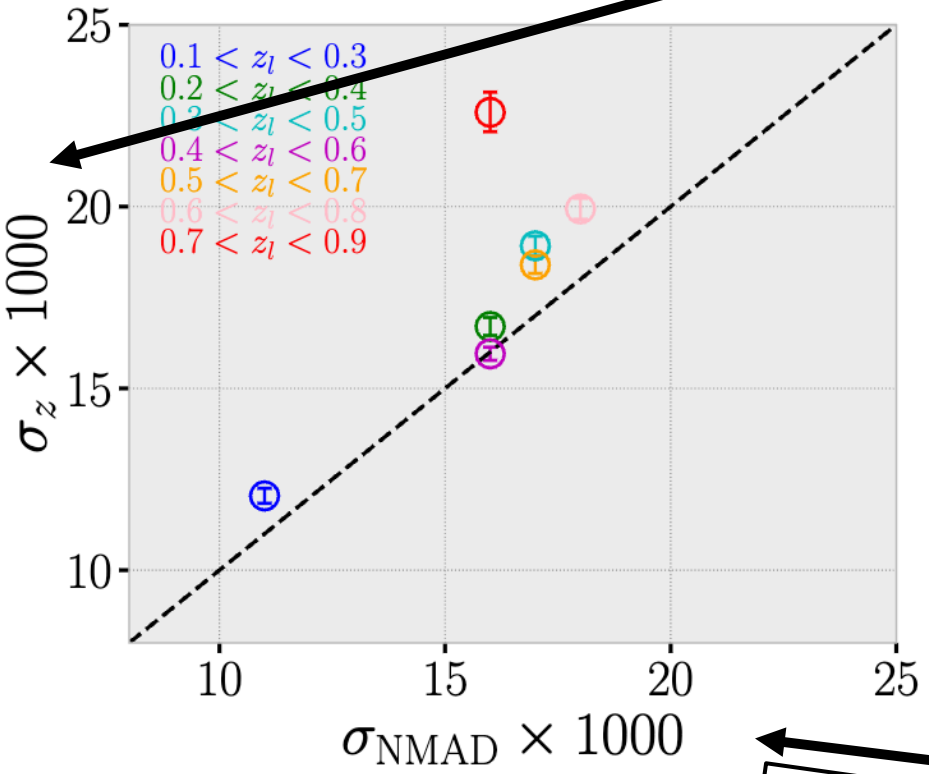
galaxy color-redshift relation



Xu+ 2023, to be submitted

Two tests

large-scale structure



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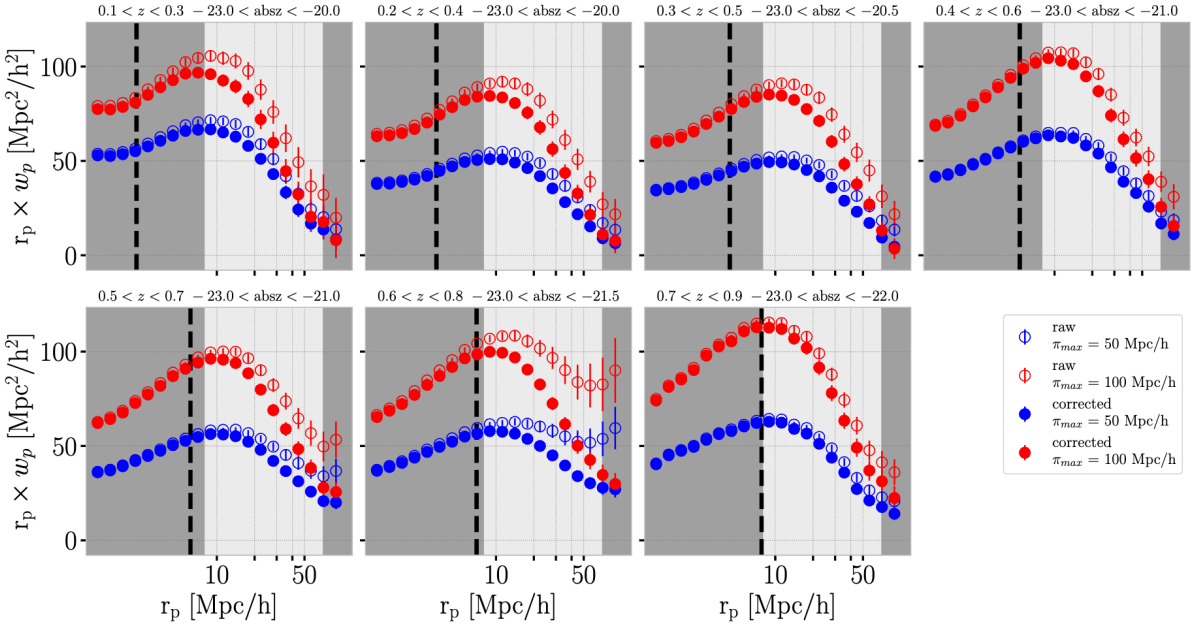

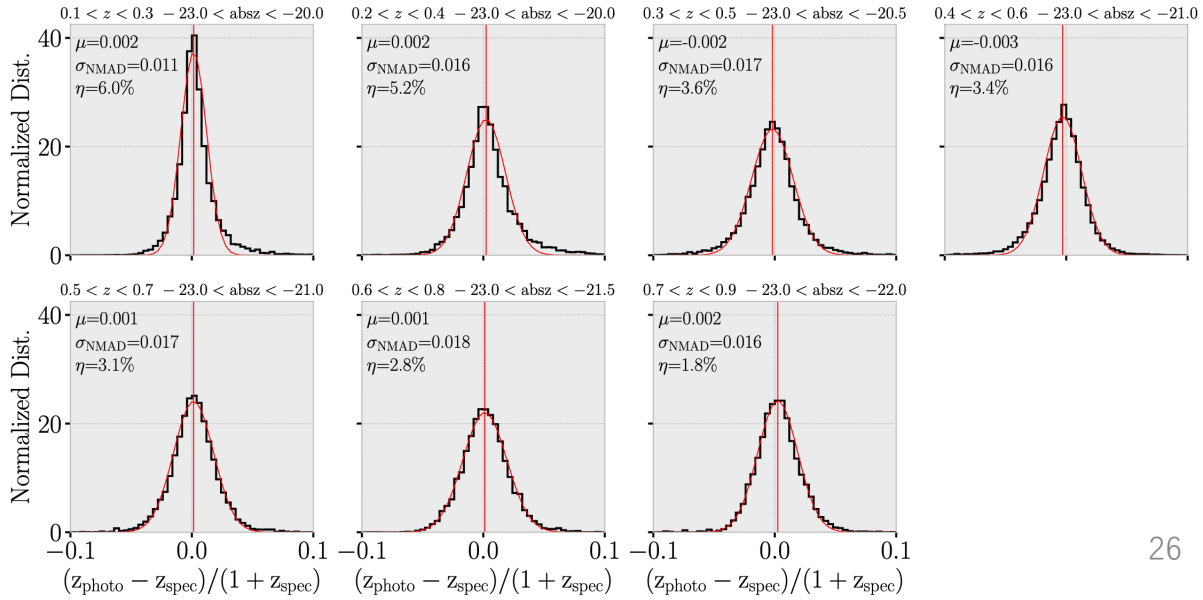

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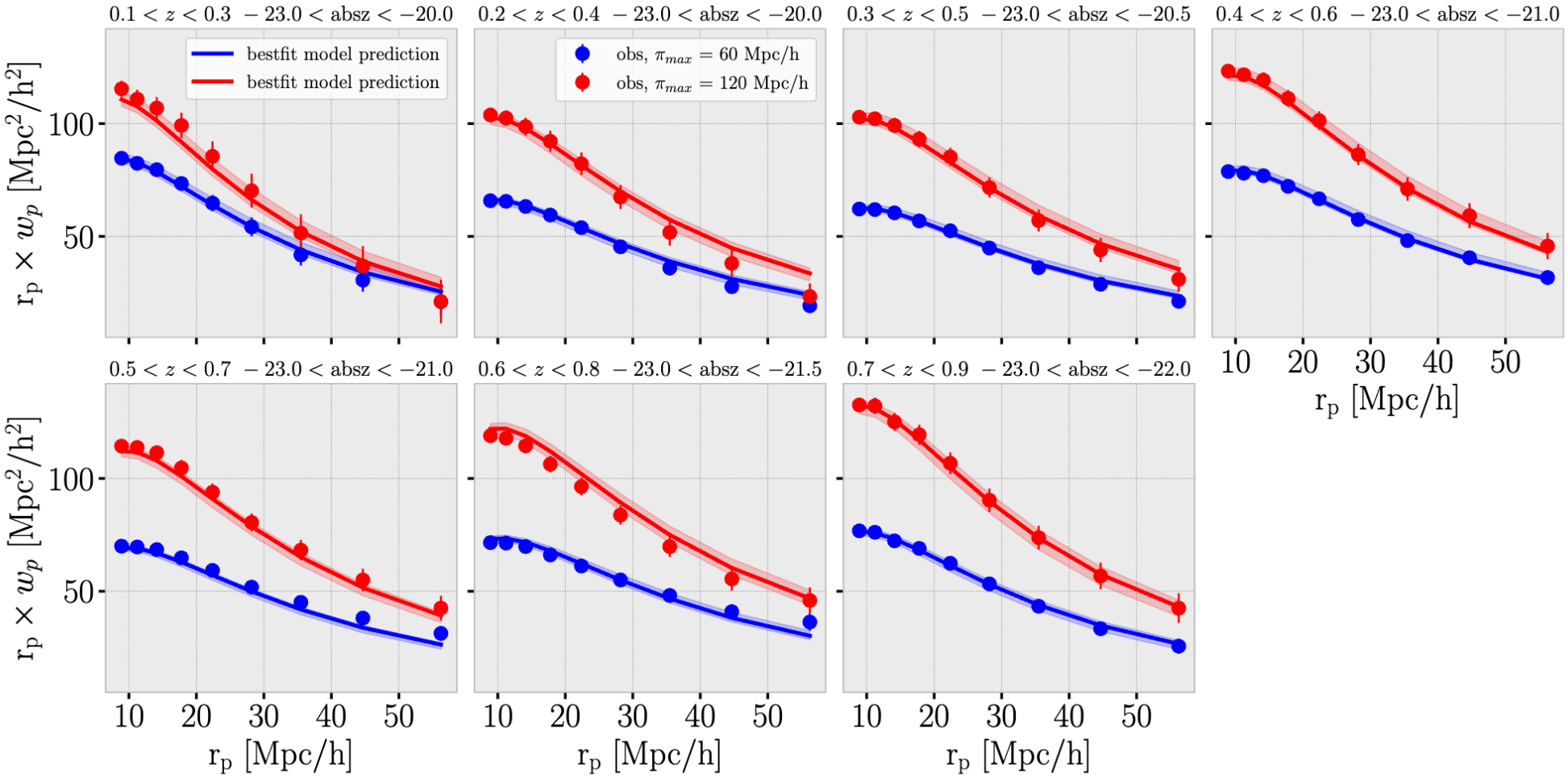

Xu+ 2023, to be submitted

Future prospects

- Imaging systematics
- Shape and ESD measurements
- Gaussian photo-z
- Realistic treatments of catastrophic outliers
- Intrinsic alignments
- Magnification bias
- Covariance matrix
- Incorporate the statistical uncertainties of Planck constraints
- …

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More manpower!

Future prospects

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- Magnification bias
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- Different lens: galaxy groups

Take-home messages:

- Large lens samples
  - precise 2PCFs measurements
- Abundant sources galaxies
  - precise lensing measurements
- Tight constraints on the cosmological parameters
  - $\sigma_{S_8} \sim 0.02$
- Mild S_8 dependence on lens redshift
  - need more checks

Back-up slides

z_l	$M_z^{0.5} - 5\log h$	$N_{gal,l}$	$\eta \times 10^{-2}$	$\bar{z}_l$	$\bar{z}_s$	$\alpha_{\rm mag}$	χ_r^2	σ_z	b_g	σ_8	Ω_m	S_8
[0.1, 0.3]	[-23.0, -20.0]	4.76×10^6	6.0	0.23	0.67	3.0	0.94	$0.012^{+0.0002}_{-0.0002}$	$1.22^{+0.02}_{-0.02}$	$0.72^{+0.03}_{-0.03}$	$0.39^{+0.02}_{-0.02}$	$0.82^{+0.03}_{-0.03}$
[0.2, 0.4]	[-23.0, -20.0]	6.82×10^6	5.2	0.32	0.74	2.8	0.91	$0.016^{+0.0002}_{-0.0002}$	$1.18^{+0.02}_{-0.02}$	$0.80^{+0.02}_{-0.02}$	$0.35^{+0.01}_{-0.01}$	$0.87^{+0.02}_{-0.02}$
[0.3, 0.5]	[-23.0, -20.5]	7.33×10^6	3.6	0.41	0.82	2.7	1.06	$0.019^{+0.0003}_{-0.0003}$	$1.20^{+0.02}_{-0.02}$	$0.81^{+0.03}_{-0.03}$	$0.34^{+0.01}_{-0.01}$	$0.86^{+0.03}_{-0.03}$
[0.4, 0.6]	[-23.0, -21.0]	5.46×10^6	3.4	0.50	0.88	2.6	1.22	$0.016^{+0.0002}_{-0.0002}$	$1.24^{+0.03}_{-0.02}$	$0.84^{+0.03}_{-0.03}$	$0.34^{+0.01}_{-0.01}$	$0.89^{+0.04}_{-0.04}$
[0.5, 0.7]	[-23.0, -21.0]	7.12×10^6	3.1	0.61	0.96	2.6	1.39	$0.018^{+0.0002}_{-0.0002}$	$1.27^{+0.03}_{-0.03}$	$0.84^{+0.05}_{-0.05}$	$0.34^{+0.01}_{-0.01}$	$0.90^{+0.05}_{-0.06}$
[0.6, 0.8]	[-23.0, -21.5]	3.97×10^6	2.8	0.70	1.02	2.5	1.92	$0.020^{+0.0003}_{-0.0003}$	$1.24^{+0.04}_{-0.04}$	$0.97^{+0.07}_{-0.08}$	$0.33^{+0.01}_{-0.01}$	$1.02^{+0.08}_{-0.09}$
[0.7, 0.9]	[-23.0, -22.0]	1.87×10^6	1.8	0.81	1.10	2.4	0.80	$0.023^{+0.0005}_{-0.0005}$	$1.38^{+0.16}_{-0.08}$	$0.91^{+0.13}_{-0.20}$	$0.35^{+0.02}_{-0.02}$	$0.98^{+0.16}_{-0.22}$

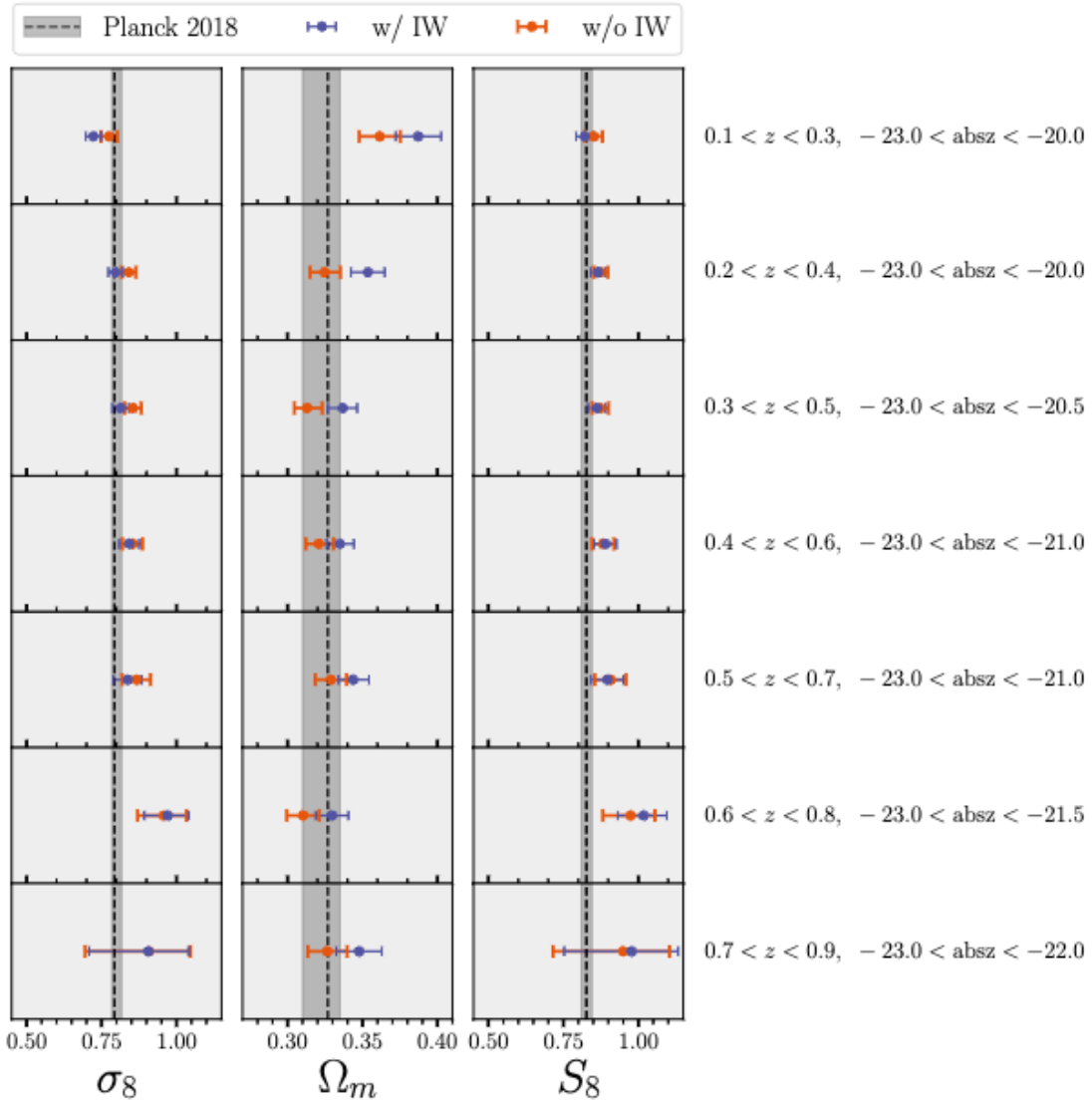

Figure 12 Comparison of cosmological parameters constraints with (blue) and without (orange) imaging systematics correction in the lens sample.

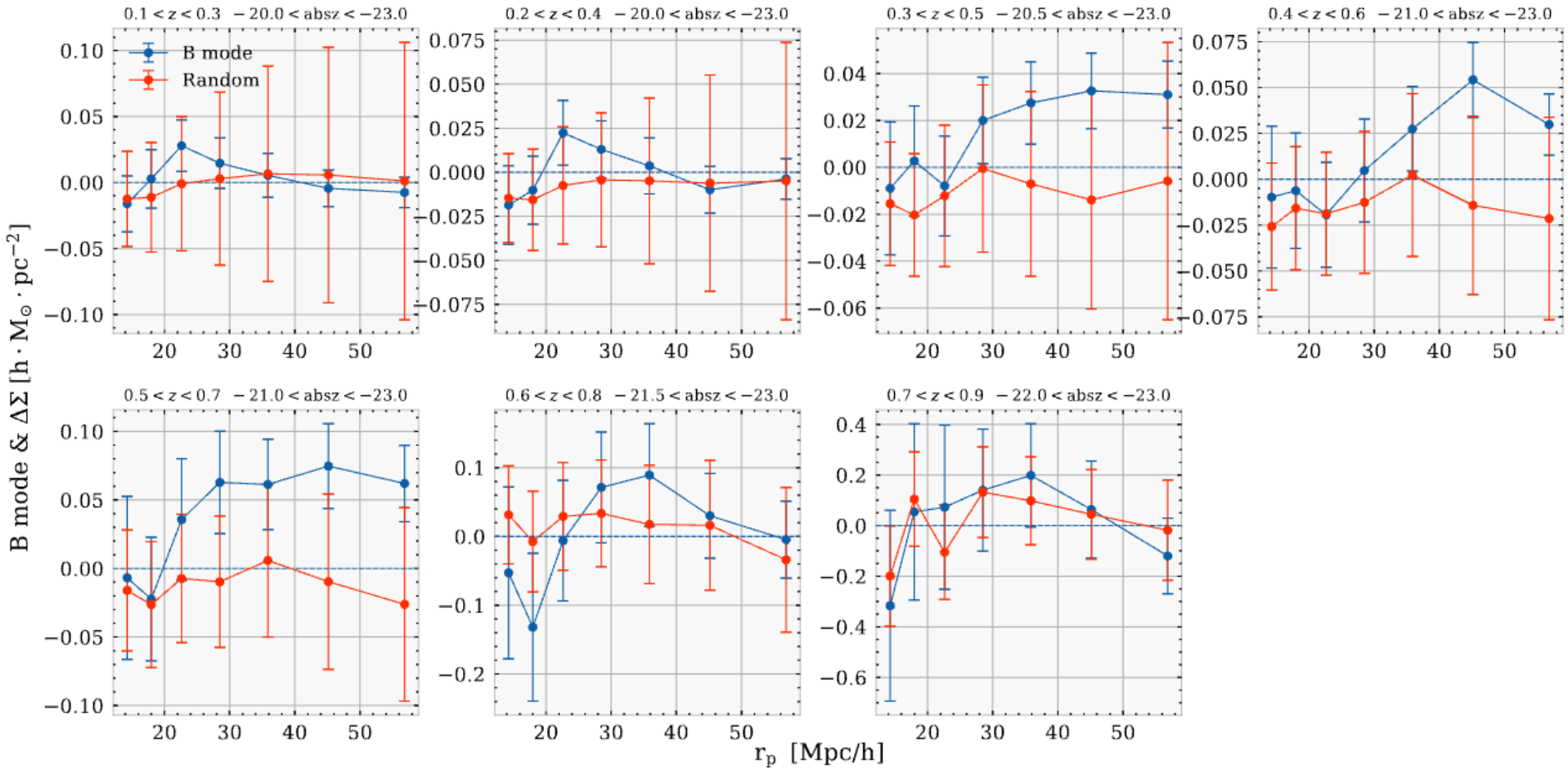

Figure A14 The B mode (blue) from lens sample and the ESDs measured around the random (red).

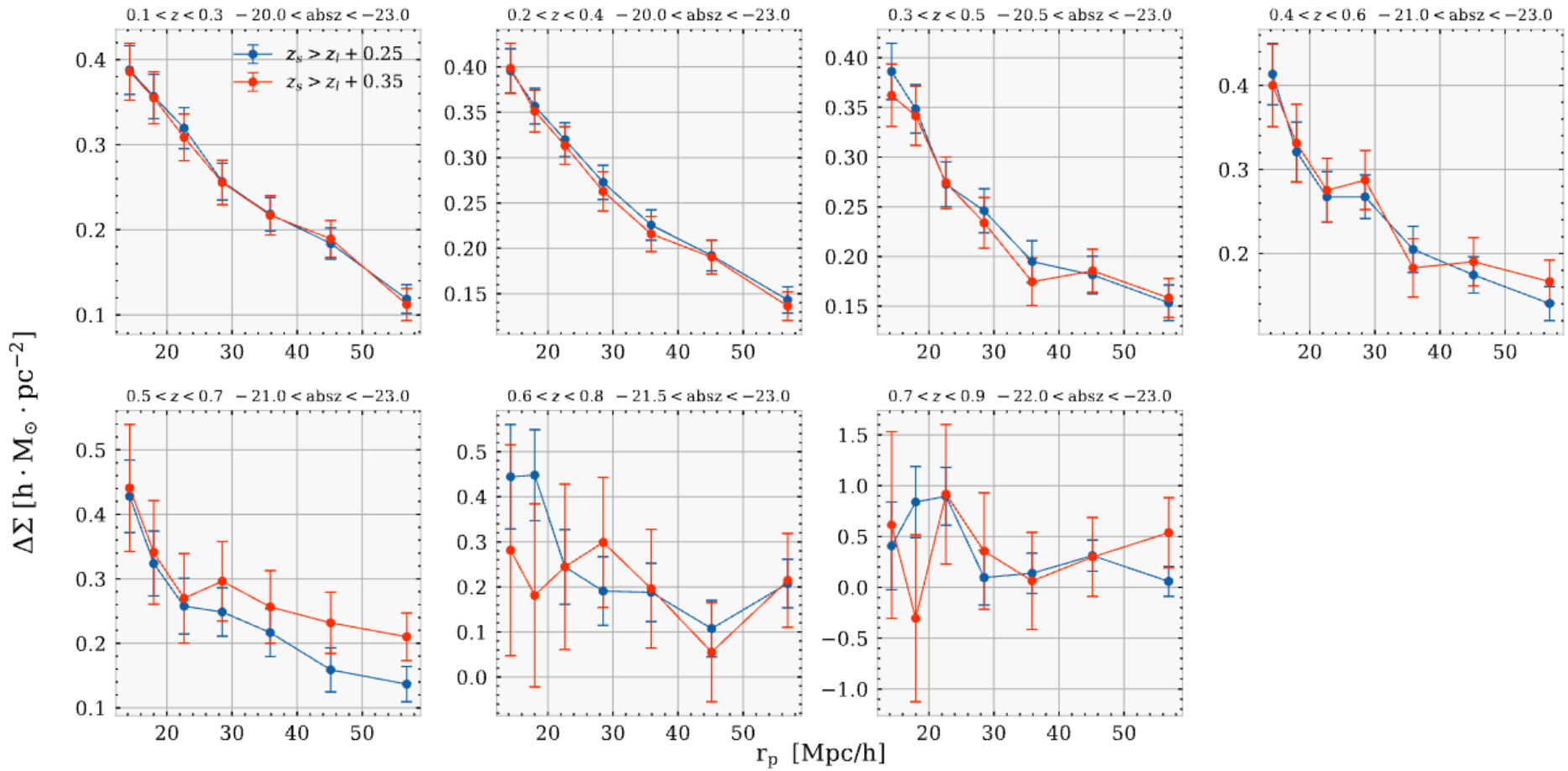

Figure A15 The comparsion of ESD measurements with a different lens-sources photo-z separation. The ESDs measured with a larger lens-sources photo-z separation ($\Delta z = 0.35$, red) is statistically consistent with the fiducial measurements ($\Delta z = 0.25$, blue) .